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Water Loss Test Results for Lateral A Before and After Lining Hidalgo County Irrigation District No. 2

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Water Loss Test Results for Lateral A, Before and After Lining Hidalgo County Irrigation District No.2

Summary

Four sets of water loss tests have been completed on segments of Lateral A canal in Hidalgo County Irrigation District No.2 (HCID2). The first tests were conducted in September 2002 and January 2003. In October 2004, Lateral A was lined with a geomembrane (geo-textile) liner overlaid with 3-inches of shotcrete (Figure 1). Two follow-up sets of water loss tests were completed in November 2004 and July 2005.

Tables 1 and 2 summarize the test results. It's important to note that two different types of tests were conducted using the ponding method (see next section). Using the ponding method, we measured the *seepage loss rate* in Segment A-7 and the *total water loss rate* in Segment A-8. We found that the lining system significantly reduced seepage losses in Segment A-7, and that the performance of the lining material improved over time, with seepage losses reduced by 82% after 1 month and by 94% after 8 months.

Table 2 lists the total loss rates for Segment A-8. A total loss test is conducted in canal segments which contain gates and valves. Frequently, gates and valves have undetected leaks, or leaks that are difficult to measure. Total water losses were still significantly reduced by 24% a month after lining and 81% eight months later.

We also tested two other canal segments, Lateral A-9 and A-11, in September 2002 and January 2003. The results were as follows:

- Lateral A-9 – seepage losses of 1.17 gal/ft²/day (111.20 ac-ft/mi/yr).
- Lateral A-11 – total losses of 1.98 gal/ft²/day (227.14 ac-ft/mi/yr).

No additional tests were conducted on these segments. The complete report on these two tests is posted at <http://idea.tamu.edu>.



Figure 1. Layering of the new lining on Lateral A.

Table 1. Seepage Loss Test Results for Lateral A, Segment A-7 of HCID2.

Test ID	Test Date	Seepage Rate		Seepage Losses (ac-ft/mile)		Seepage Losses with Evaporation (ac-ft/mile)	
		ft ³ /ft ² /hr	gal/ft ² /day	per day	per year*	per day	per year*
SJ5	Sept 2002	0.0076	1.36	0.367	134.10	0.38	139.30
The following tests were conducted after the segment was relined October 2004.							
SJ13	Nov 2004	0.0016	0.27	0.068	24.70	0.07	26.80
SJ15	July 2005	0.0005	0.09	0.024	8.60	0.04	14.80

* Annual water amounts given are based on an in-service of 365 days.

Table 2. Total Loss Test Results for Lateral A, Segment A-8 of HCID2.

Test ID	Test Date	Seepage Rate		Total Losses (ac-ft/mile)		Total Losses with Evaporation (ac-ft/mile)	
		ft ³ /ft ² /hr	gal/ft ² /day	per day	per year*	per day	per year*
SJ6	Jan 2003	0.0102	1.83	0.40	147.50	0.41	149.40
The following tests were conducted after the segment was relined October 2004.							
SJ12	Nov 2004	0.0074	1.33	0.31	111.40	0.32	117.70
SJ14	July 2005	0.0016	0.29	0.08	28.10	0.10	35.20

* Annual water amounts given are based on an in-service of 365 days.

Testing Program and Results

Seepage and total water loss rates are measured using the ponding method. In this method, the two ends of a canal segment are closed or sealed with earthen dams (Figure 2). Once sealed, water elevations were taken for at least 48 hours. Three staff-gauge stands are placed throughout the test segments and manually recorded (Figure 3). During the tests, staff-gauge stand elevations and canal dimensions, including cross section, depth and side slopes are surveyed and measured using a GPS survey-grade instrument (Figure 4). This information is used in combination with water level changes to calculate the seepage and total water loss rates.

Tests are classified as follows:

- Seepage loss tests – canal segments that do not contain valves and gates; thus, all water loss is due to seepage through the canal.
- Total loss tests – canal segments which contain valves and gates; leakage through gates and valves may contribute to the measured losses.



Figure 2. Backhoe used to construct the earthen dam on nonding test.

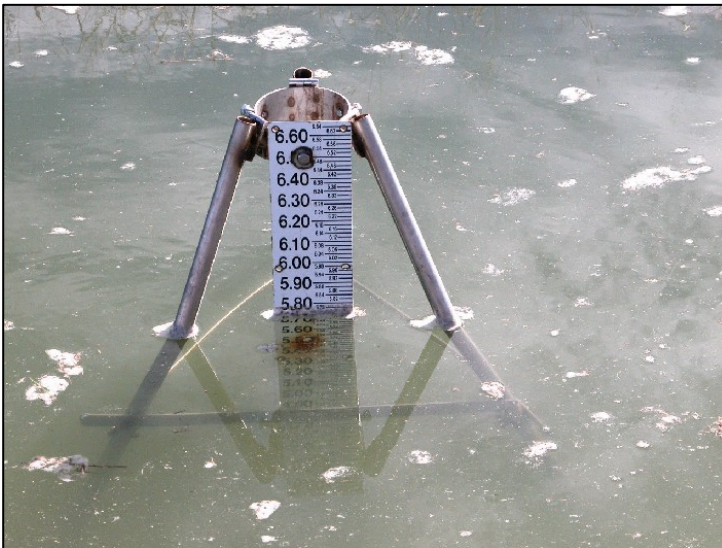


Figure 3. Staff gage stands are place in the center of the test segment.



Figure 4. Survey-grade GPS equipment used to determine the cross-section of the canal (Lateral A).

Test Location

Lateral A is located in the southern area of HCID2, running west to east just south of Military Hwy 281 (Figure 5) and is approximately 7.24 miles long (38,000 ft).

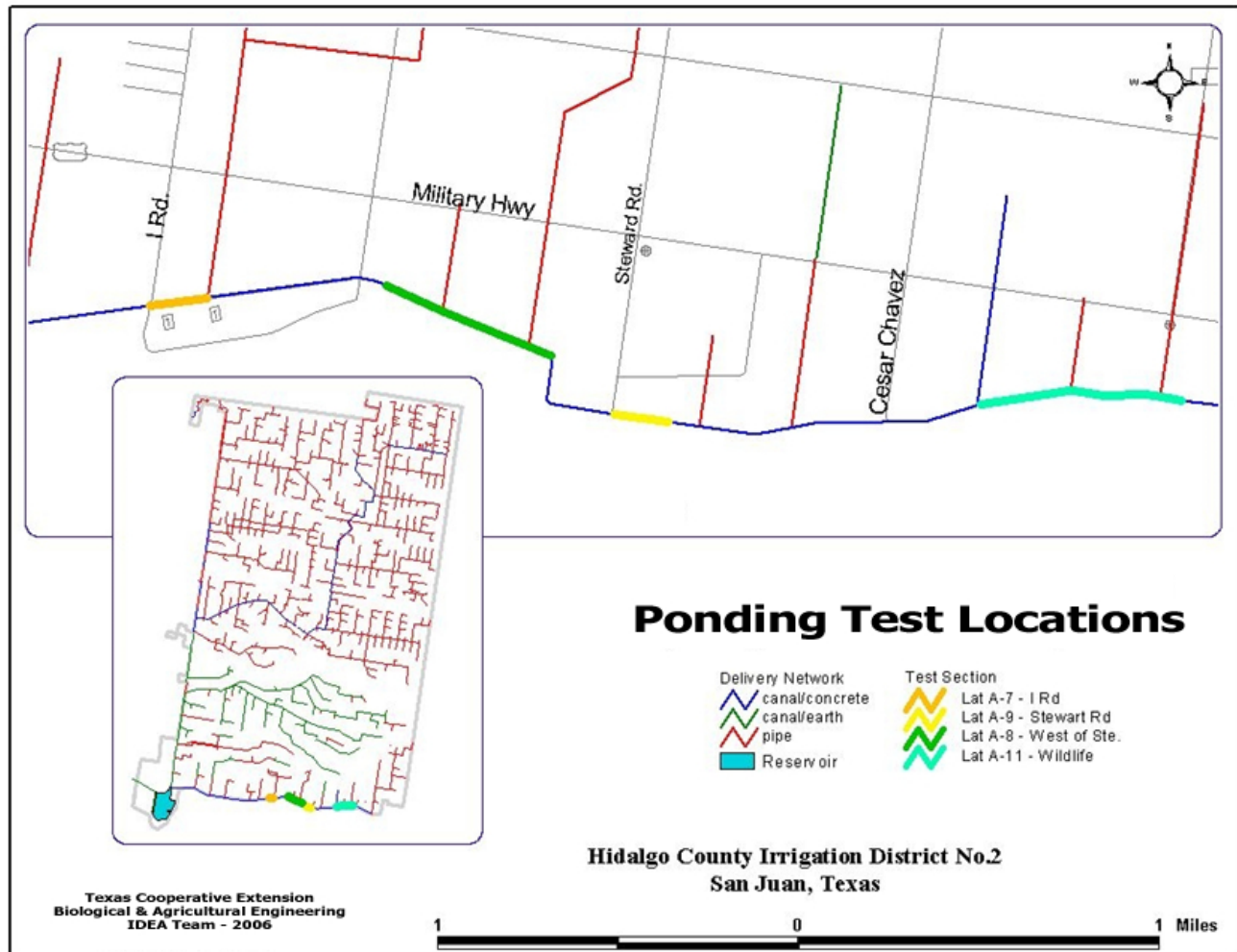


Figure 5. District map and locations of test segment for Lateral A.

Results and Discussion

Test results are summarized in Table 1 and 2. Additional data is given in Tables 3 and 4 including estimated evaporation change in water level, and volume loss rates. Evaporation rates were calculated from local weather station data. The weather data can be found at <http://texaset.tamu.edu>.

We have tested segments Lateral A-7 and A-8 three times to date, once in September 2002 and January 2003, respectively, and then twice following the lining (geomembrane overlaid with 3 inches of shotcrete) installation in October 2004.

Lateral A-7

We found that the lining system significantly reduced seepage losses of Lateral A-7, and that the performance of the lining system increased over time. One month after lining, seepage losses were reduced 82% compared to the test conducted in September 2002. In July 2005, we retested the segment and found that seepage losses continued to decrease. Losses fell by 35% since the test in November, and were 94% lower when compared to pre-lining conditions in September 2002.

Table 3. Additional Test Result Information for Lateral A, <u>Segment A-7</u> of HCID2.							
Test ID	Starting Depth (ft)	Evaporation		Δ Water Level		Seepage Rate	
		in/day	ft/day	in/day	ft/day	ft ³ /ft ² /hour	gal/ft ² /day
SJ5	4.75	0.108	0.009	3.00	0.25	0.0076	1.36
The following tests were conducted after the segment was relined October 2004.							
SJ13	4.32	0.050	0.004	0.58	0.05	0.0016	0.27
SJ15	4.81	0.130	0.011	0.24	0.02	0.0005	0.09

Lateral A-8

The total loss test results for Lateral A-8 were reduced by 24% in November when compared with the pre-lining test conducted in January 2003. Eight months after lining, total water losses were reduced by 81% compared to the tests conducted in 2003.

Leaks were discovered at several gates and valves with in the test segment. However, these losses could not be accounted for due to the difficulties in obtaining measurements.

Table 4. Additional Test Result Information for Lateral A, <u>Segment A-8</u> of HCID2.							
Test ID	Starting Depth (ft)	Evaporation		Δ Water Level		Total Loss Rate	
		in/day	ft/day	in/day	ft/day	ft ³ /ft ² /hour	gal/ft ² /day
SJ6	3.70	0.048	0.004	4.03	0.34	0.0102	1.83
The following tests were conducted after the segment was relined October 2004.							
SJ12	3.88	0.050	0.004	2.79	0.233	0.0074	1.33
SJ14	4.50	0.140	0.012	0.65	0.054	0.0016	0.29

Appendix A

Detailed Test Results

Lateral A-7

Table 5. Data for Test SJ13 – Lateral A-7 (‘I’ Rd.)								
District		Hidalgo County Irrigation District No.2			Test ID		SJ13	
Canal		Lateral A-7			Lining Type		Concrete/GeoLiner	
Top Width		15.77 feet (avg.)			Start Date/Time		Finish Date/Time	
Test Length		802 feet			Nov.30, 2004		Dec.2, 2004	
Total Depth		5.7 feet (avg.)			16:10		16:17	
Location: Off of ‘I’ Road, south of Military Hwy (281).								
Staff Gage Readings								
Date		SG1		SG2		SG3		
		Readings	Time	Readings	Time	Readings	Time	
1	30-Nov.	5.08	16:10	1.72	16:12	4.94	16:14	
2		5.10	17:10	1.74	17:12	4.94	17:14	
3	1-Dec.	5.05	11:00	1.69	11:01	4.90	11:03	
4		5.05	14:11	1.68	14:13	4.89	14:17	
5	2-Dec.	4.99	09:18	1.64	09:20	4.85	09:22	
6		4.99	11:10	1.63	11:14	4.85	11:16	
7		4.98	14:18	1.63	14:20	4.84	14:23	
8		4.98	16:13	1.62	16:15	4.84	16:17	
Adjust. Factor		-0.884		2.454		-0.701		

Table 6. Data for Test SJ15 – Lateral A-7 (‘I’ Rd.)							
District		Hidalgo County Irrigation District No.2		Test ID		SJ15	
Canal		Lateral A-7		Lining Type		Concrete/GeoLiner	
Top Width		15.77 feet (avg.)		Start Date/Time		Finish Date/Time	
Test Length		802 feet		July 27, 2005		July 29, 2005	
Total Depth		5.7 feet (avg.)		15:20		15:05	
Location: Off of ‘I’ Road, south of Military Hwy (281).							
Staff Gage Readings							
Date		SG1		SG2		SG3	
		Readings	Time	Readings	Time	Readings	Time
1	27-July	1.92	15:20	2.39	15:22	5.55	15:24
2		1.92	17:23	2.39	17:25	5.55	17:27
3	28-July	1.89	09:17	2.36	09:19	5.52	09:21
4		1.89	11:19	2.36	11:21	5.52	11:23
5		1.89	13:23	2.36	13:25	5.52	13:27
6		1.89	15:18	2.36	15:20	5.52	15:22
7		1.89	17:15	2.36	17:17	5.52	17:20
8	29-July	1.87	09:10	2.34	09:12	5.50	09:14
9		1.87	11:15	2.34	11:17	5.50	11:19
10		1.87	15:01	2.34	15:03	5.50	15:05
Adjust. Factor		2.945		2.475		-0.852	



Figure 6. Earthen dam on Lat. A-7. (Test SJ15)

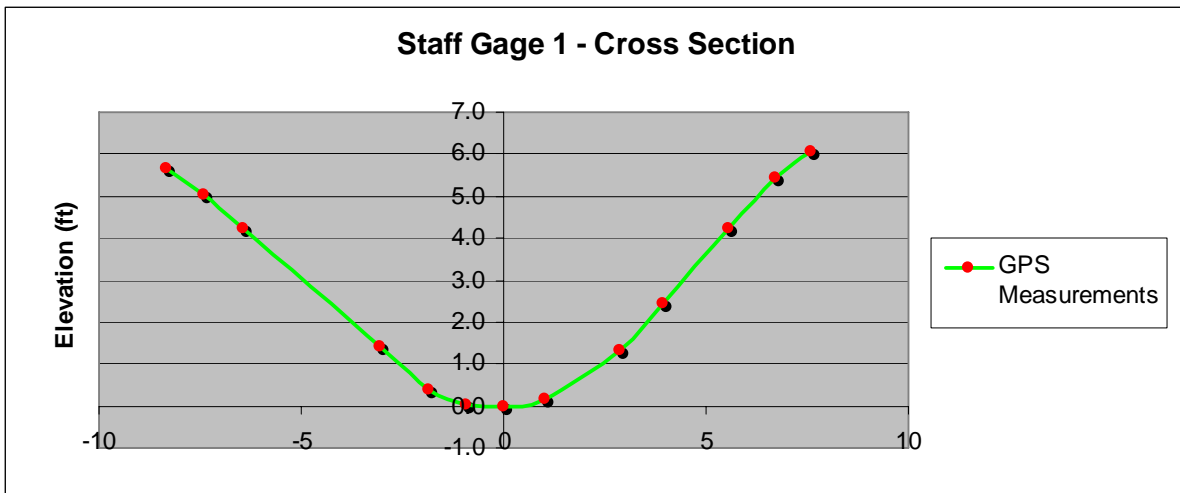


Figure 7. Cross-section of Staff Gage 1 of Lateral A-7.

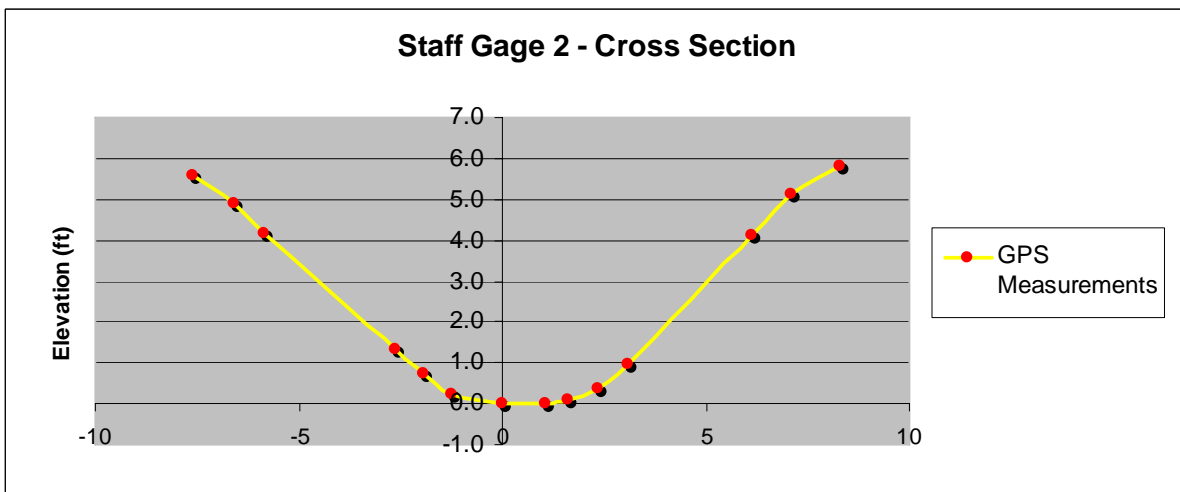


Figure 8. Cross-section of Staff Gage 2 of Lateral A-7.

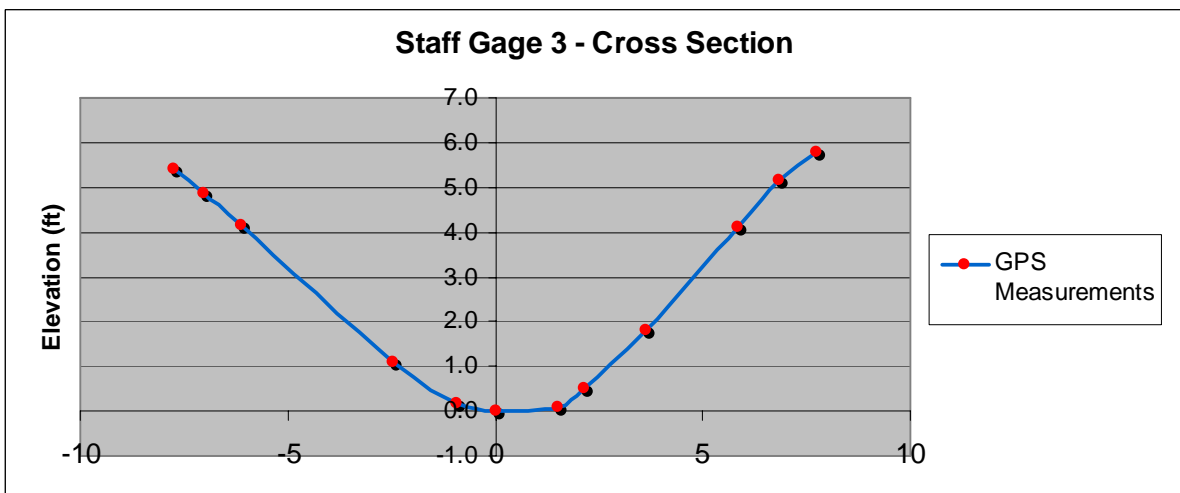


Figure 9. Cross-section of Staff Gage 3 of Lateral A-7.

Lateral A-8

Table 7. Data for Test SJ12 – Lateral A-8 (West of Stewart Rd.)							
District		Hidalgo County Irrigation District No.2		Test ID		SJ12	
Canal		Lateral A-8		Lining Type		Concrete/GeoLiner	
Top Width		15.977 feet (avg.)		Start Date/Time		Finish Date/Time	
Test Length		2602 feet		Nov.30, 2004		Dec.2, 2004	
Total Depth		5.265 feet (avg.)		16:00		16:10	
Location: West of Stewart Road, south of Military Hwy (281).							
Staff Gage Readings							
Date		SG1		SG2		SG3	
		Readings	Time	Readings	Time	Readings	Time
1	30-Nov.	4.60	16:00	4.52	16:03	1.06	16:03
2		4.60	17:00	4.52	17:03	1.04	17:03
3	1-Dec.	4.41	10:40	4.33	10:45	0.87	10:45
4		4.385	14:03	4.30	14:06	0.84	14:06
5	2-Dec.	4.20	09:04	4.10	09:08	0.65	09:08
6		4.18	11:00	4.08	11:06	0.63	11:06
7		4.16	14:06	4.06	14:10	0.61	14:10
8		4.14	16:00	4.04	16:10	0.59	16:10
Adjust. Factor		-0.773		-0.673		2.647	



Figure 10. Earthen dam on Lat.A-8. (Test SJ12)

Table 8. Data for Test SJ14 – Lateral A-8 (West of Stewart Rd.)							
District		Hidalgo County Irrigation District No.2		Test ID		SJ14	
Canal		Lateral A-8		Lining Type		Concrete/GeoLiner	
Top Width		15.977 feet (avg.)		Start Date/Time		Finish Date/Time	
Test Length		2602 feet		July 26, 2005		July 28, 2005	
Total Depth		5.265 feet (avg.)		17:08		17:11	
Location: West of Stewart Road, south of Military Hwy (281).							
Staff Gage Readings							
Date		SG1		SG2		SG3	
		Readings	Time	Readings	Time	Readings	Time
1	26-July	5.24	17:08	5.10	17:10	1.69	17:12
2		5.24	18:12	5.10	18:10	1.69	18:08
3	27-July	5.20	09:02	5.06	09:04	1.65	09:06
4		5.20	11:14	5.06	11:16	1.65	11:18
5		5.19	13:12	5.05	13:14	1.64	13:16
6		5.19	15:14	5.05	15:16	1.64	15:18
7		5.18	17:10	5.04	17:12	1.63	17:14
8	28-July	5.14	09:08	5.00	09:10	1.59	09:12
9		5.14	11:13	5.00	11:15	1.59	11:17
10		5.14	13:16	5.00	13:18	1.59	13:20
11		5.13	15:10	4.99	15:12	1.58	15:14
12		5.12	17:07	4.98	17:09	1.57	17:11
Adjust. Factor		-0.64		-0.60		2.71	



Figure 11. This photograph shows a standpipe connecting off of Lateral A-8 leaking during test. Leaks like this are very difficult to measure and are usually hard to notice.

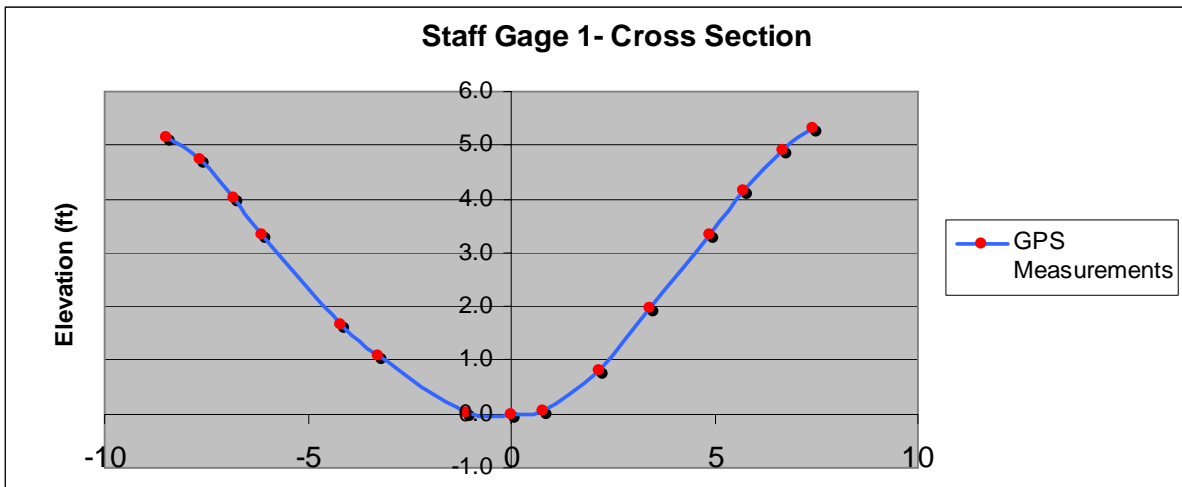


Figure 12. Cross-section of Staff Gage 1 of Lateral A-8.

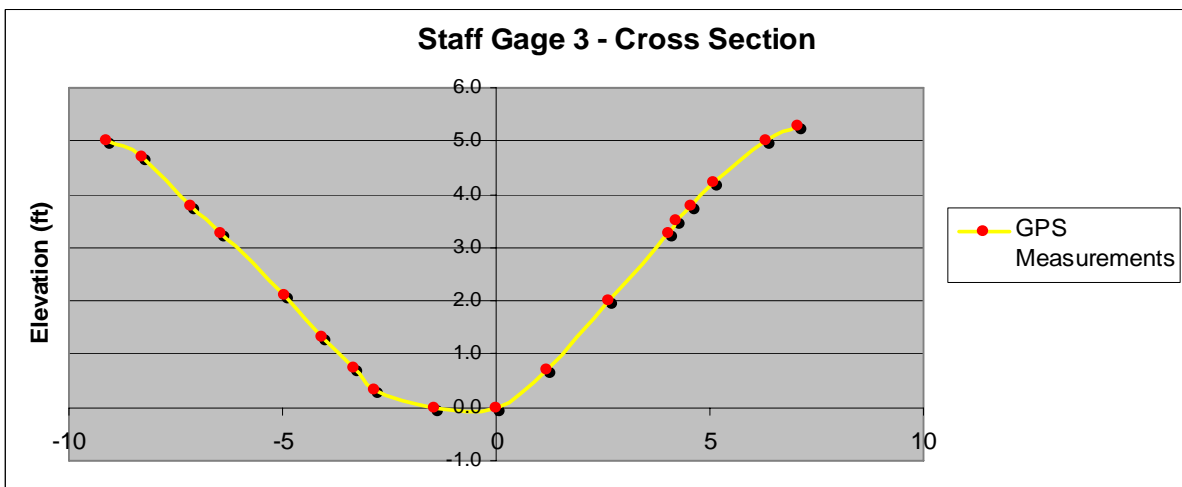


Figure 13. Cross-section of Staff Gage 2 of Lateral A-8.

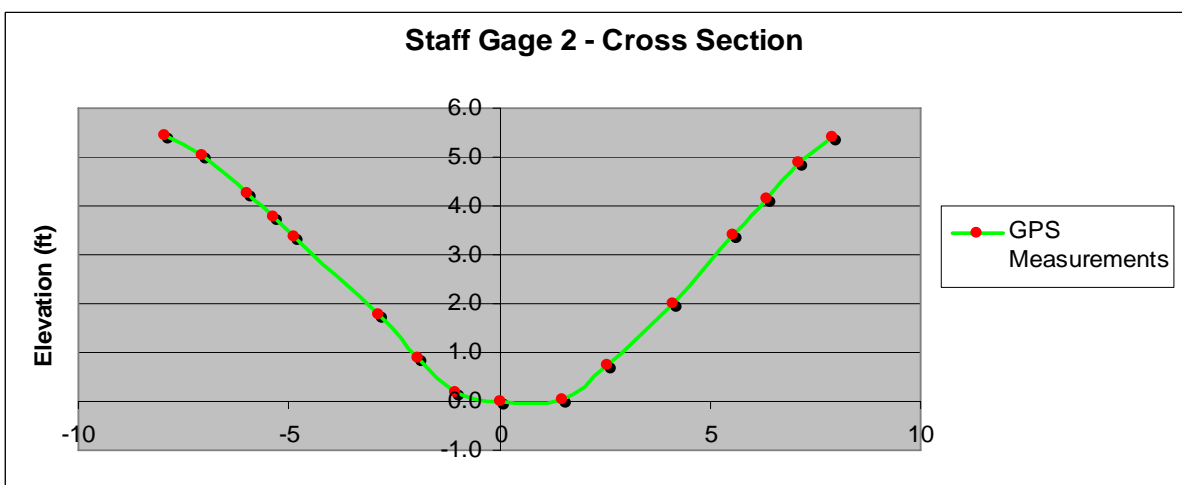


Figure 14. Cross-section of Staff Gage 3 of Lateral A-8.

Appendix B:

Groundwater Measurements

Table 9. Canal and groundwater elevations (feet) taken in 2002.		
Test Segment	M	N
Lat. A-9	9.93	8.31
Lat.A-7	8.75	6.3

M) Groundwater level elevation from to natural ground from (Figure 13).

N) Canal water level elevation from natural ground (figure 13).

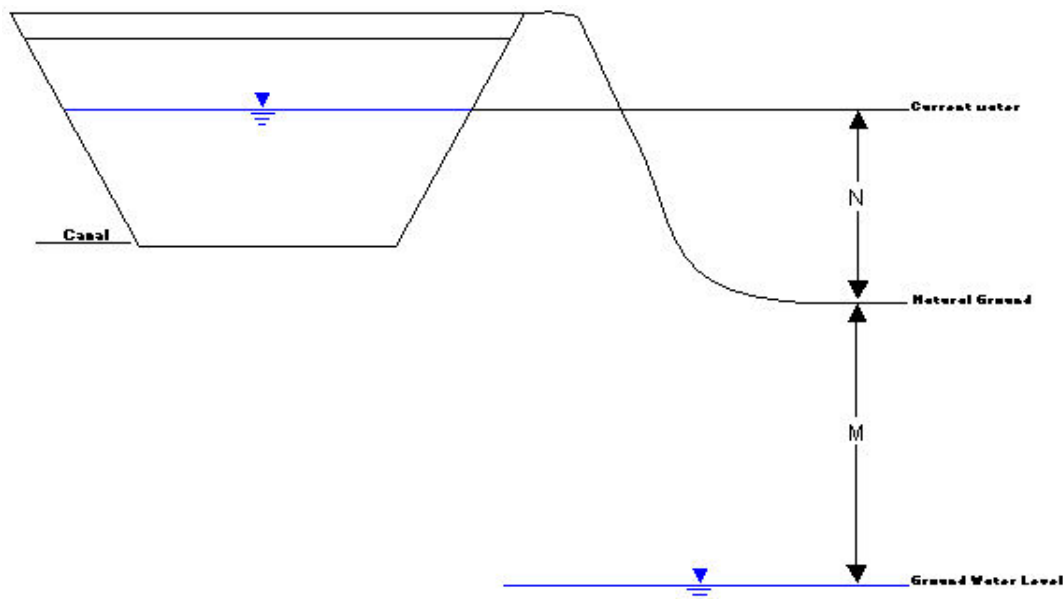


Figure 15. Groundwater measurement diagram.

Soil Descriptions²

General Soil Series

9 – Harlingen-Runn-Reynosa: Deep, very slowly, slowly, and moderately permeable soils that typically have a grayish brown clay, silty clay, or silty clay loam surface layer.

2 – Rio Grande-Matamoros: Deep, moderate and slowly permeable soils that typically have a light brownish gray brown silt loam or silty clay surface layer.

² Soil Surveys of Hidalgo County, USDA, SCS, TAES (1979)

Detailed Soil Units

Table 10: Detailed Soil Units / Permeability	
Soil Unit ³	Permeability In/hr
07 – Cameron silty clay	0.2 – 6.0
19 – Harlingen clay	< 0.06
55 – Reynosa silty clay loam	0.6 – 2.0
64 – Runn silty clay	0.06 – 0.6

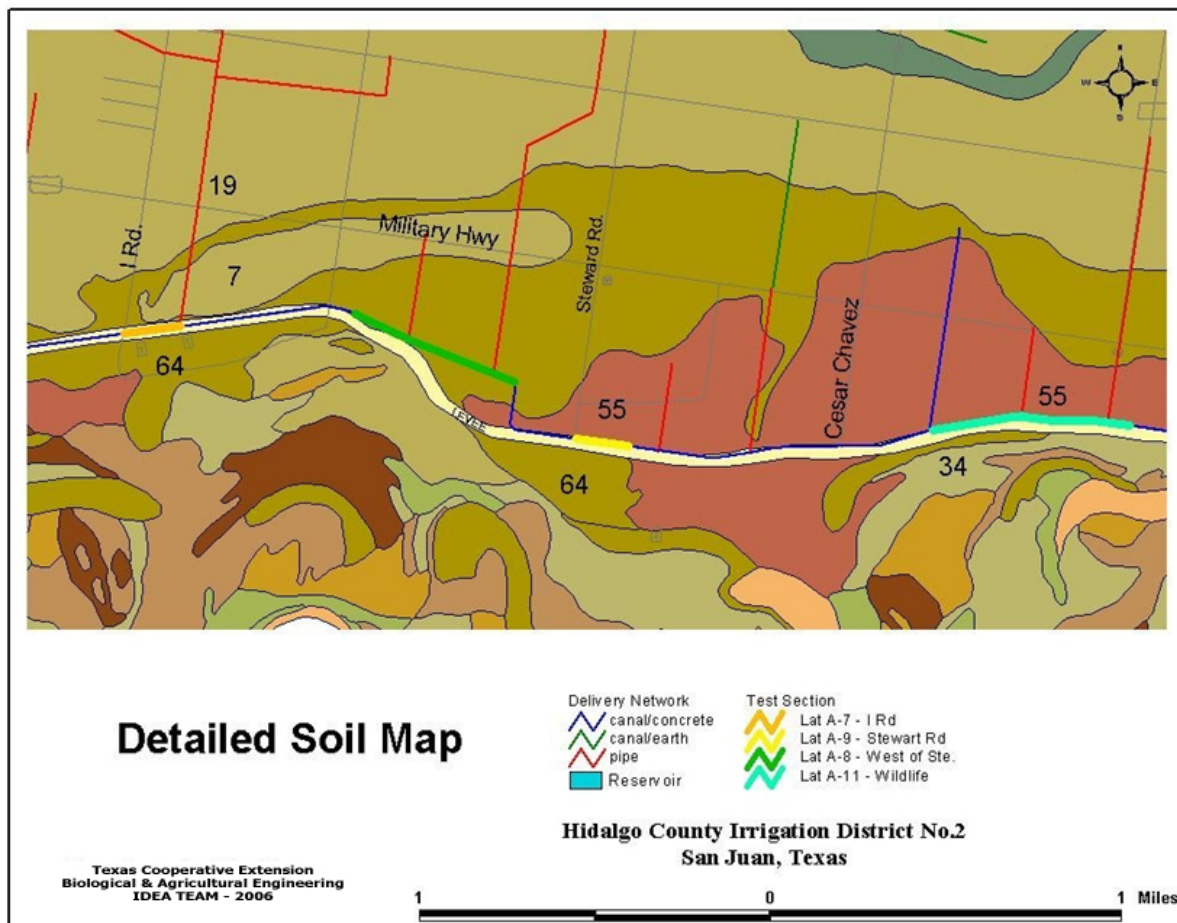


Figure 16. Map showing detailed soil map with ponding test site locations (see table 10).

³ See Detailed Soil Map (Figure 16).

Appendix C: Other Test Results

Texas Cooperative Extension has conducted approximately 50 total loss tests and seepage loss tests in the Lower Rio Grande River Basin since 1998. The results are summarized in Tables 11 – 13. Table 14 gives seepage rates versus lining type as reported in the scientific literature.

Table 11. Results of seepage loss tests conducted by Texas Cooperative Extension in the Lower Rio Grande River Basin.						
Test ID	Year	Canal Width (ft)	Canal Depth (ft)	*Class	<u>Loss Rate</u> gal/ft2/day ac-ft/mi/yr	
<u>Lined</u>						
16HC2	03			M		
LF1	03	12	5	M	1.77	152.9
LF2	03	10	6	M	4.61	369.1
MA4	03	12	5	S	8.85	529.7
SJ4	00	15	4	M	1.17	111.2
SJ5	02	14	5	M	1.38	145.5
UN1	01	12	6	M	2.32	217.7
UN2	01	8	3	M	2.09	121.2
<u>Unlined</u>						
BR1	03	60	11	M	3.14	794.6
MA3	03	19	5	S	13.9	1690.1
RV1	03	38	4	M	0.15	23.0
SB4	02	16	4	S	0.64	68.3
SB5	02	18	3	S	1.67	188.3
SB6	02	20	5	S	1.44	189.0
SB7	02	16	4	S	0.42	47.4
SB8	02	20	5	S	0.83	104.0

*Classification of canal: M = main, S = secondary

Table 12. Results of total loss tests in lined canals (leaking gates and valves may have contributed to measured loss rates) conducted by Texas Cooperative Extension in the Lower Rio Grande River Basin.

Test ID	Year	Canal Width (ft)	Canal Depth (ft)	*Class	Loss Rate	
					gal/ft2/day	ac-ft/mi/yr
<u>Lined</u>						
16HC1	03	14	5	M	1.89	192.4
BV1	99	10	5	M	7.97	510.5
BV2	99	9	4	M	8.53	451.5
DL1	00	20	6	M	0.16	18.8
DL2	00	7	4	S	4.12	236.2
DO1	03	5	3	S	1.68	65.2
DO2	03	6	4	S	2.18	121.5
DO3	03	6	3	S	2.71	107.2
ED1	00	6	4	S	34.32	1519.6
ED2	00	6	4	S	21.5	858.2
ED3	00	3	2	T	10.22	308.2
ED4	00	4	3	S	18.72	567.7
ED6	99	9	4	M	8.53	451.5
HA2	00	10	4	M	2.26	135.2
HA3	98	15	2	S	0.64	45.5
ME1	98	38	7	M	1.26	281.9
ME2	98		4	M	1.88	163.5
SJ1	99	12	5	M	2.58	126.8
SJ6	03	12	3	M	1.88	1.63
SJ7	03	19	4	M	1.98	227.1
UN3	02	12	6	M	2.02	154.3

*Classification of canal: M = main, S = secondary, T = tertiary

Table 13. Results of total loss tests in unlined canals (leaking gates and valves may have contributed to measured loss rates) conducted by Texas Cooperative Extension in the Lower Rio Grande River Basin.

Test ID	Year	Canal Width (ft)	Canal Depth (ft)	*Class	<u>Loss Rate</u>	
					gal/ft ² /day	ac-ft/mi/yr
BV3	99	55	8	M	0.15	53.4
ED5	02	105	7	M	2.39	1213.2
MA1	99	50	10	M	1.98	227.1
MA2	99	20	5	S	4.32	371.4
SB1	00	29	7	S	1.27	215.5
SJ2	00	23	6	M	2.74	293.2
SJ3	00	30	5	S	0.95	132.6

*Classification of canal: M = main, S = secondary

Table 14. Canal seepage rate reported in published studies.

Lining/soil type	Seepage rate (gal/ft ² /day)
Unlined ¹	2.21-26.4
Portland cement ²	0.52
Compacted earth ²	0.52
Brick masonry lined ³	2.23
Earthen unlined ³	11.34
Concrete ⁴	0.74 - 4.0
Plactic ⁴	0.08-3.74
Concrete ⁴	0.06-3.22
Gunit ⁴	0.06-0.94
Compacted earth ⁴	0.07-0.6
Clay ⁴	0.37-2.99
Loam ⁴	4.49-7.48
Sand ⁴	4.0-19.45

¹DeMaggio (1990). Technical Memorandum: San Luis unit drainage program project files. US Bureau of Reclamation, Sacramento. ²U.S. Bureau of Reclamation (1963). Lining for Irrigation Canals. ³Nayak, et al. (1996). The influence of canal seepage on groundwater in Lugert Lake irrigation area. Oklahoma Water Resources Research Institute. ⁴Nofziger (1979). Profit potential of lining watercourses in coastal commands of Orissa. Environment and Ecology 14(2):343-345.

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